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(54) **LOW FLYING HEAD DETECTION USING READBACK SIGNAL AMPLITUDE MODULATION**

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(51) **Int. Cl.**
G11B 5/02 (2006.01)
G11B 27/36 (2006.01)
G11B 21/02 (2006.01)

(52) **U.S. Cl.** **360/25**; 360/31; 360/75

(58) **Field of Classification Search** 360/73.01, 360/73.03, 75
See application file for complete search history.

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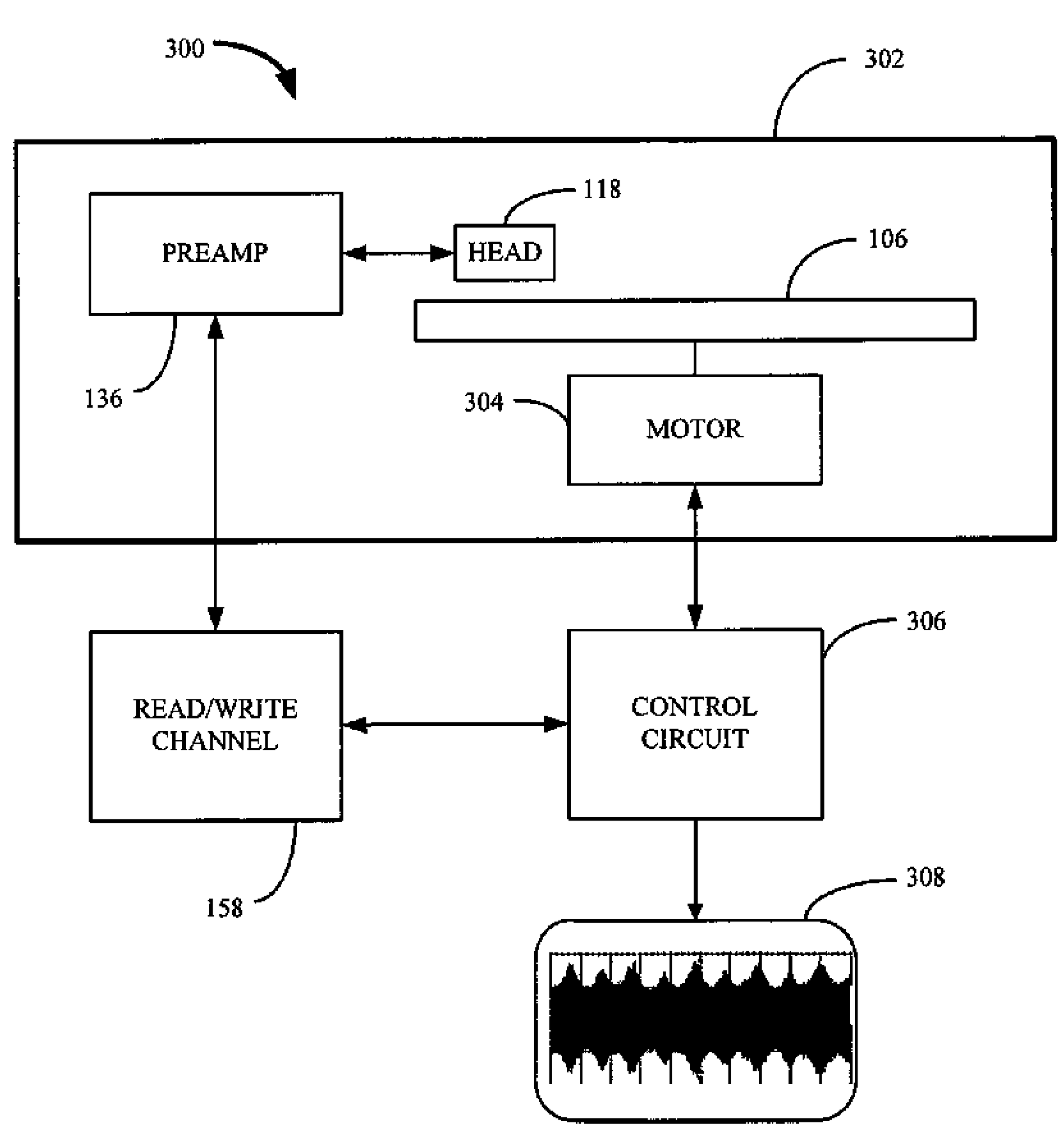
(57) **ABSTRACT**

A method for determining whether a data storage device read/write head is a low-flying read/write head or a non low-flying read/write head. A disc attached to a spindle motor is accelerated to an operating rotational velocity, the head is positioned over a portion of the disc non-accessible to customer data and a data pattern of selected frequency is written. A magnetoresistive element of the is biased and the data pattern is read while the disc is decelerated to a predetermined rotational velocity threshold. Occurrence of a read signal landing signature comprising readback signal amplitude modulation prior to reaching the predetermined rotational velocity threshold identifies the head as a low-flying head. Contrawise, non-occurrence of the read signal landing signature prior to reaching the predetermined rotational velocity threshold signifies the head as a non low-flying head.

13 Claims, 4 Drawing Sheets



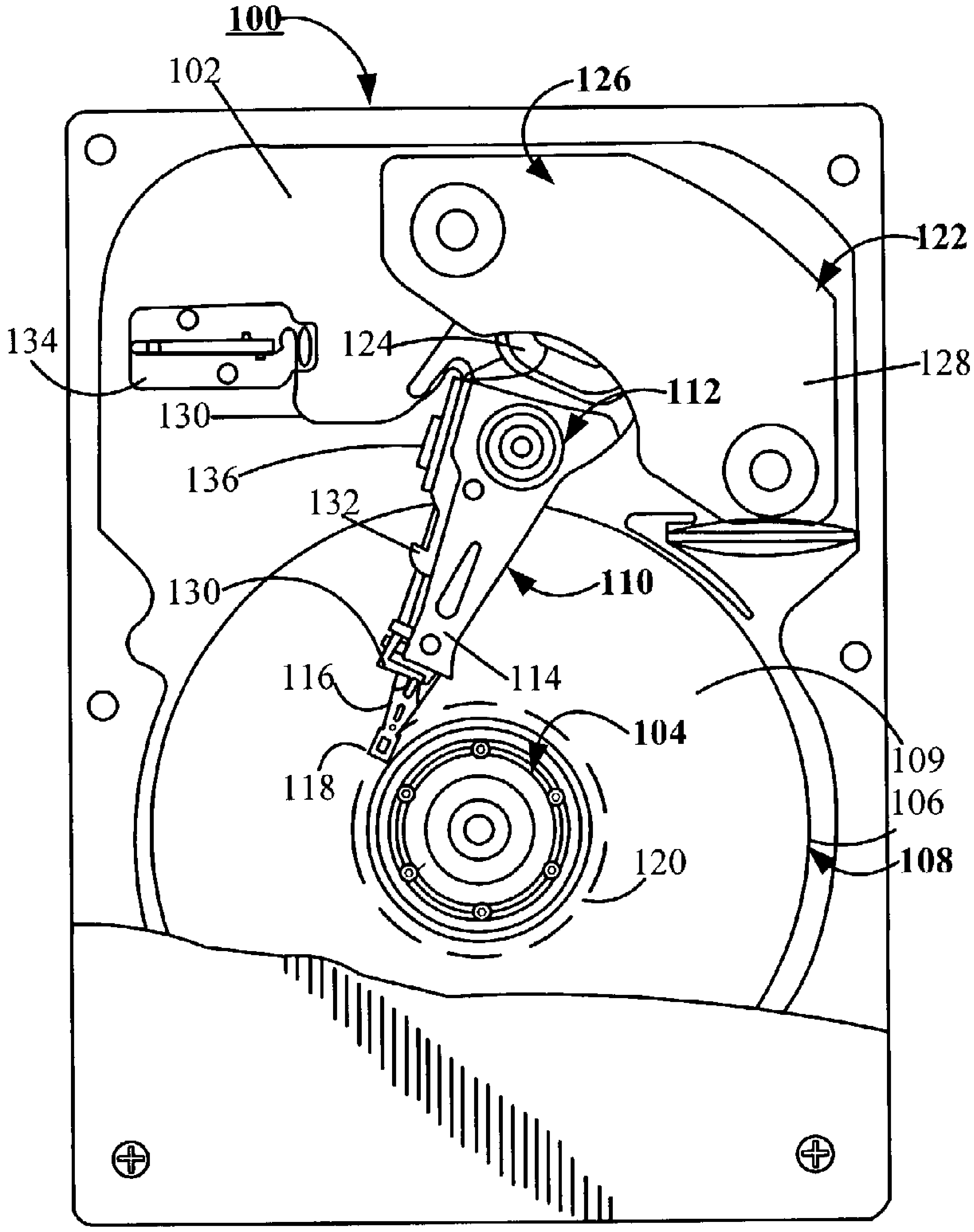

100
102
126
122
134
124
128
130
112
136
132
110
130
116
114
104
109
118
106
120
108

FIG. 1

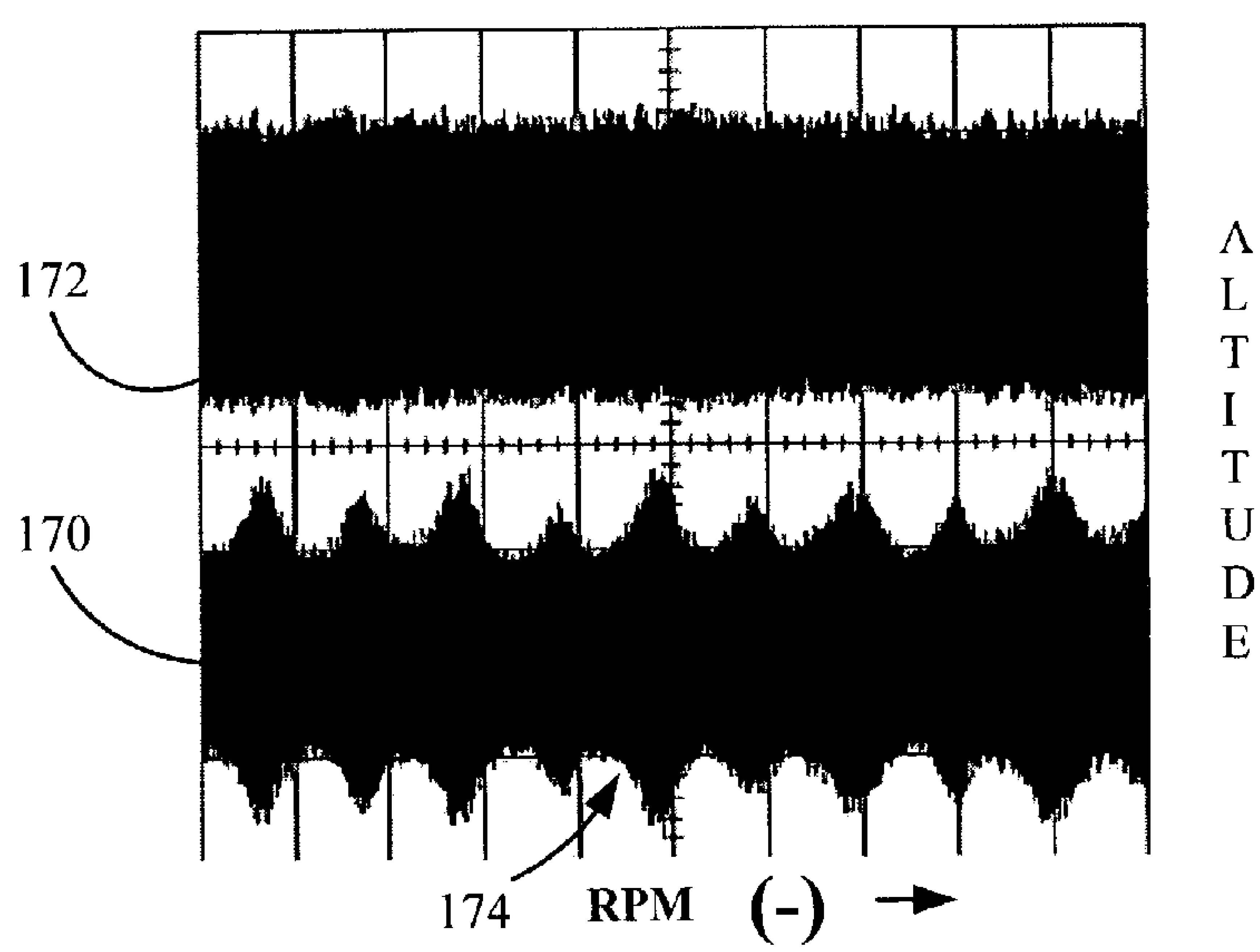

172
170
ALTITUDE
174
RPM (-)

FIG. 3

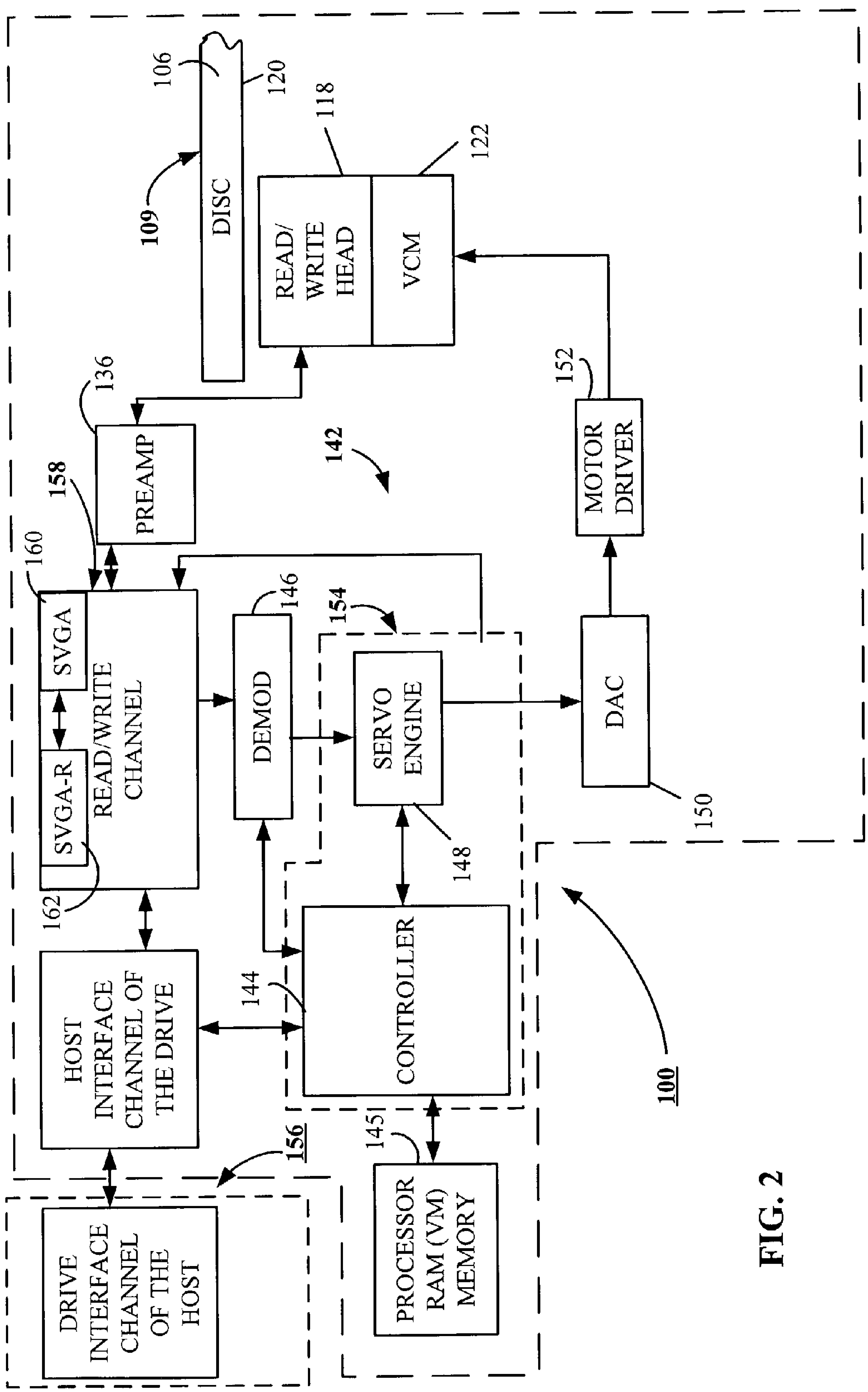

DISC
106
120
109
118
122
READ/
WRITE
HEAD
VCM
136
PREAMP
142
152
MOTOR
DRIVER
158
160
SVGA
SVGA-R
READ/WRITE
CHANNEL
162
146
DEMOD
154
SERVO
ENGINE
148
DAC
150
CONTROLLER
144
HOST
INTERFACE
CHANNEL OF
THE DRIVE
145
PROCESSOR
RAM (VM)
MEMORY
156
DRIVE
INTERFACE
CHANNEL
OF THE
HOST
100

FIG. 2

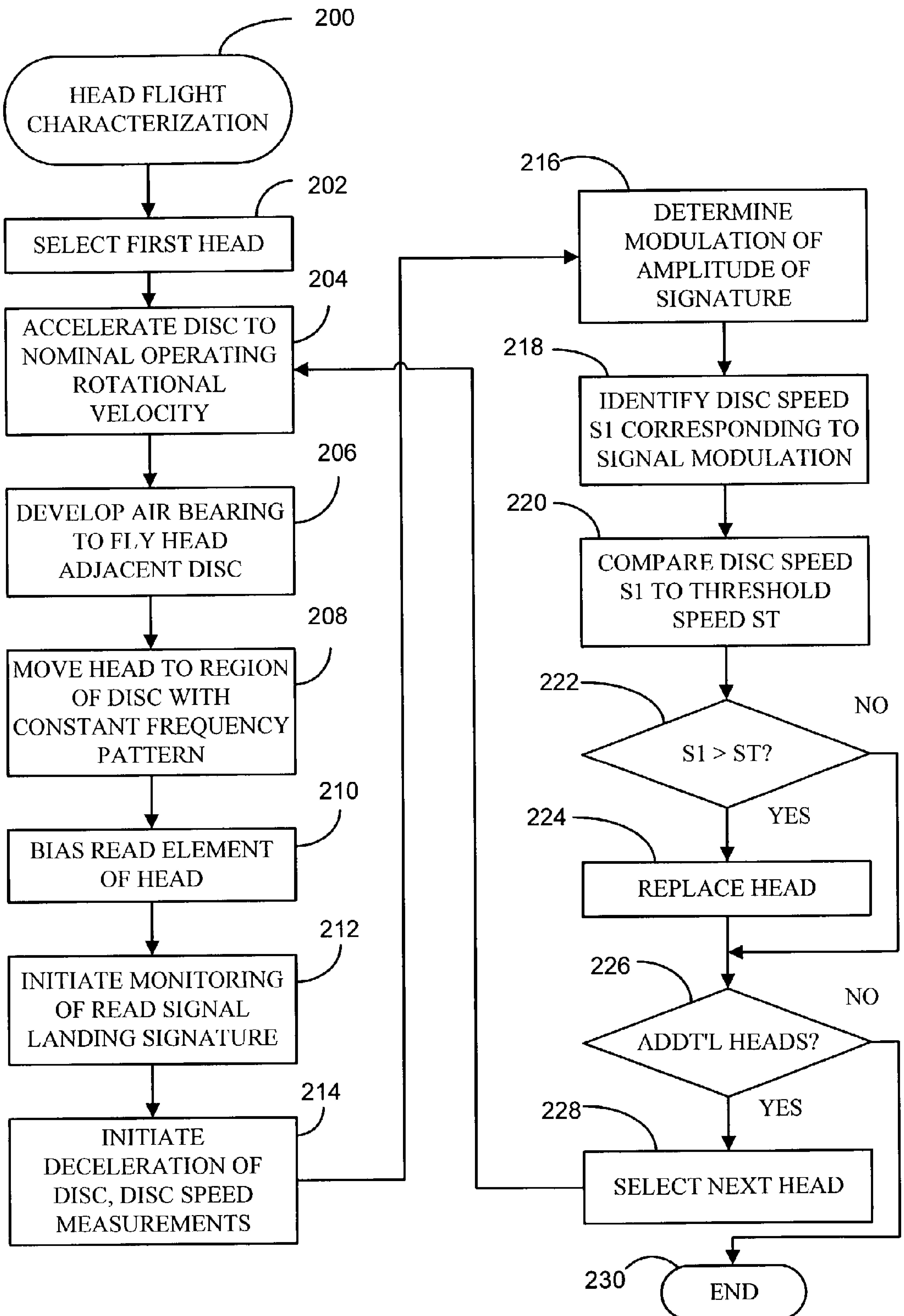

200
HEAD FLIGHT CHARACTERIZATION
202
SELECT FIRST HEAD
204
ACCELERATE DISC TO NOMINAL OPERATING ROTATIONAL VELOCITY
206
DEVELOP AIR BEARING TO FLY HEAD ADJACENT DISC
208
MOVE HEAD TO REGION OF DISC WITH CONSTANT FREQUENCY PATTERN
210
BIAS READ ELEMENT OF HEAD
212
INITIATE MONITORING OF READ SIGNAL LANDING SIGNATURE
214
INITIATE DECELERATION OF DISC, DISC SPEED MEASUREMENTS
216
DETERMINE MODULATION OF AMPLITUDE OF SIGNATURE
218
IDENTIFY DISC SPEED S1 CORRESPONDING TO SIGNAL MODULATION
220
COMPARE DISC SPEED S1 TO THRESHOLD SPEED ST
222
S1 > ST?
NO
YES
224
REPLACE HEAD
226
ADDT'L HEADS?
NO
YES
228
SELECT NEXT HEAD
230
END

FIG. 4

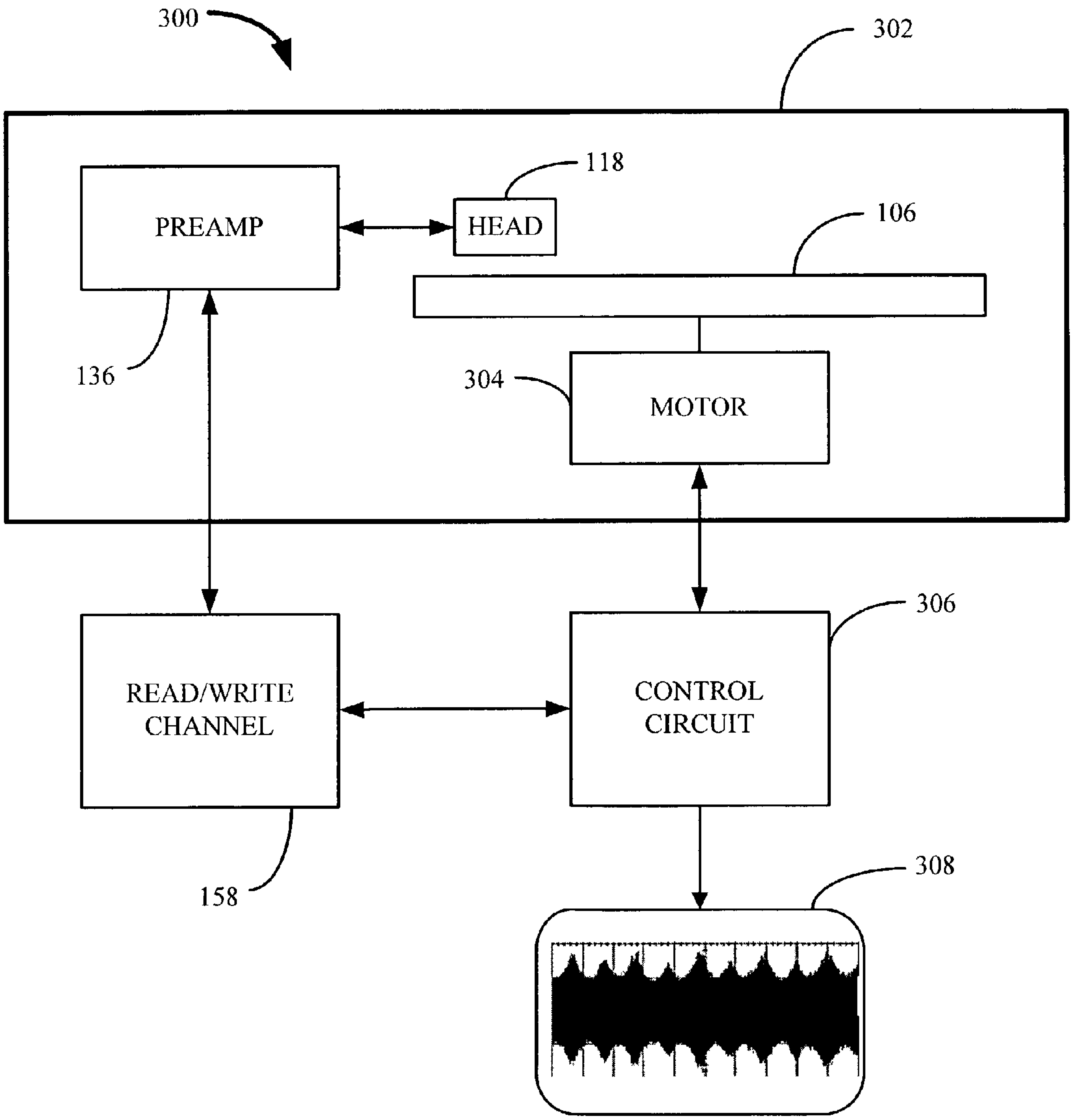

300
302
PREAMP
118
HEAD
106
136
304
MOTOR
306
READ/WRITE
CHANNEL
CONTROL
CIRCUIT
158
308

FIG. 5

LOW FLYING HEAD DETECTION USING READBACK SIGNAL AMPLITUDE MODULATION

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 60/368,361 filed Mar. 28, 2002, entitled Detecting Head Fly Height Using Motor Spin Down.

FIELD OF THE INVENTION

This invention relates generally to the field of magnetic data storage devices, and more particularly, but not by way of limitation, to identifying a low flying read/write head of a disc drive based on a read signal landing signature response.

BACKGROUND

Disc drives are used for data storage in modern electronic products ranging from digital cameras to computers and network systems. Typically a disc drive includes a mechanical portion and an electronics portion in the form of a printed circuit board assembly that controls functions of the mechanical portion while providing a communication interface to a host being serviced by the disc drive.

Typically, the mechanical portion, or head-disc assembly, has a disc with a recording surface rotated at a constant speed by a spindle motor assembly and an actuator assembly positionably controlled by a closed loop servo system for use in accessing the stored data. The actuator assembly commonly supports a magnetoresistive read/write head that writes data to and reads data from the recording surface. Normally, the magnetoresistive read/write head uses an inductive element, or writer, to write data to and a magnetoresistive element, or reader, to read data from the recording surface.

The disc drive market continues to place pressure on the industry for disc drives with increased capacities, higher data rates and lower costs. A key aspect of achieving lower costs is an identification of marginal components as early as practical in the manufacturing process to preclude needless accrual of additional manufacturing costs and costly rework operations in subsequent processes. Additionally, an ability to identify, remove and replace marginal components from a disc drive prior to shipment is an aid in reduction of field failure and warranty expense.

A critical component of a disc drive is the magnetoresistive read/write head. As each read/write head passes through manufacturing processes in preparation for use in a disc drive, costs associated with those processes accrue and contribute to the overall cost of the disc drive. By measuring characteristics of the read/write head throughout the manufacturing process, defective and marginal read/write heads can be culled from the process before additional costs are needlessly applied.

Fly height of a read/write head is an important operating characteristic of the read/write head for proper operation of the disc drive. A read/write head with a fly height greater than a specified nominal fly height will typically display poor data transfer characteristics and is generally replaced. However, a read/write head with a fly height less than the specified nominal fly height will typically display good data transfer characteristics and, unless detected, is generally not replaced. An undetected low-fly head within a disc drive poses an increased risk to subsequent failure of the disc drive over the useful life of the disc drive.

As such, challenges remain and a need persists for effective techniques for determining a low-flying read/write head within a disc drive throughout the disc drive manufacturing process. It is to this and other features and advantages set forth herein that embodiments of the present invention are directed.

SUMMARY OF THE INVENTION

As exemplified herein, embodiments of the present invention are directed to categorization of a fly height status of a read/write head relative to a disc of a disc drive as either a low-flying read/write head or as a non low-flying read/write head.

Categorization of the fly height status of the read/write head is based on detection of a read signal landing signature prior to encountering a predetermined rotational velocity threshold. The read signal landing signature is preferably determined from a readback of a constant frequency pattern written to a region of the disc inaccessible for storage of customer data.

During a landing procedure, the readback of the constant frequency pattern is monitored while the disc decelerates from a nominal operating rotational velocity to a stationary state. While decelerating the disc, the read signal landing signature is formed just prior to the read/write head landing on the disc.

Occurrence of said read signal landing signature while the rotational velocity of the disc is greater than the predetermined rotational velocity threshold indicates the presence of a low-flying read/write head.

These and various other features and advantages, which characterize the present invention, will be apparent from a reading of the following detailed description and a review of the associated drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top plan view of a disc drive that incorporates a read/write head screened for low-fly height.

FIG. **2** is a functional block diagram of a circuit for controlling operation of the disc drive of FIG. **1** and in determining a fly height status of the read/write head of FIG. **1**.

FIG. **3** is a graphical representation of a typical read signal landing signature of a constant frequency pattern written to a corresponding disc as read by the read/write head prior to landing on a disc.

FIG. **4** is a flow chart of a characterization process for characterizing the fly height status of a read/write head of the disc drive of FIG. **1**.

FIG. **5** provides a functional block diagram of a system configured to carry out the routine of FIG. **4** in accordance with preferred embodiments of the present invention.

DETAILED DESCRIPTION

FIG. **1** shows a top view of a disc drive data storage device **100** constructed in accordance with preferred embodiments of the present invention. The disc drive **100** includes a basedeck **102** supporting various data storage device components including a spindle motor assembly **104** that supports one or more axially aligned rotatable discs **106** forming a disc stack **108**, each disc **106** having at least one, and usually two, recording surfaces **109**.

Adjacent the disc stack **108** is a head stack assembly **110** (also referred to as an actuator assembly) that pivots about a bearing assembly **112** in a rotary fashion. The actuator assembly **110** includes an actuator arm **114** that supports a load arm **116**, which in turn supports a read/write head **118** corresponding to the rotatable recording surface **109**. The recording surface **109** is divided into concentric information tracks **120** (only one depicted) over which the read/write head **118** is positionably located. The information tracks **120** accommodate head position control information written to embedded servo sectors (not separately depicted).

Between the embedded servo sectors are data sectors used for storing data in the form of bit patterns. The read/write head **118** includes a reader element (not separately shown) offset radially and laterally from a writer element (not separately shown). The writer element writes data to the concentric information tracks **120** while the reader element controls the positioning of the read/write head **118** relative to the concentric information tracks **120** during write operations. During read operations the reader element reads data from the concentric information tracks **120** for passage to a host (not shown) serviced by the disc drive **100** and for use by a servo control system.

The term "servoing," or "position-controlling," as used herein, means maintaining control of the read/write head **118** relative to the rotating recording surface **109** during operation of the disc drive **100**. When servoing to or servoing on a selected information track **120**, the actuator assembly **110** is controllably positioned by a voice coil motor assembly **122**. The voice coil motor assembly **122** includes an actuator coil **124** immersed in a magnetic field generated by a magnet assembly **126**. A pair of steel plates **128** (pole pieces) mounted above and below the actuator coil **124** provides a magnetically permeable flux path for a magnetic circuit of the voice coil motor **122**.

During operation of the disc drive **100**, current passes through the actuator coil **124** forming an electromagnetic field, which interacts with the magnetic circuit of the voice coil motor **122**, causing the actuator coil **124** to move relative to the magnet assembly **126**. As the actuator coil **124** moves, the actuator assembly **110** pivots about the bearing assembly **112**, causing the read/write head **118** to move over the rotatable recording surface **109**, thereby allowing the read/write head **118** to interact with the information tracks **120** of the recording surface **109**.

To provide the requisite electrical conduction paths between the read/write head **118** and read/write circuitry of the disc drive (not shown), read/write head wires (not shown) affixed to the read/write head **118** are attached to a read/write flex circuit **130**. The read/write flex circuit **130** is routed from the load arm **116** along the actuator arm **114** and into a flex circuit containment channel **132** and secured to a flex connector body **134**.

The flex connector body **134** supports the flex circuit **130** during passage through the basedeck **102** and into electrical communication with a printed circuit board assembly (PCBA), (not shown) typically mounted to the underside of the basedeck **102**.

The flex circuit containment channel **132** also supports read/write signal circuitry including a preamplifier/driver (preamp) **136** that conditions read/write signals passed between the read/write circuitry and the read/write head **118**. The printed circuit board assembly mounted to the underside of basedeck **102** provides the data storage device read/write circuitry that controls the operation of the read/write head **118**, as well as other interface and control circuitry for the disc drive **100**.

Turning to FIG. **2**, position-controlling of the read/write head **118** is provided by the positioning mechanism (not separately shown) operating under the control of a servo control circuit **142** programmed with servo control code, which forms a servo control loop.

The servo control circuit **142** includes a micro-processor controller **144** (also referred to herein as controller **144**), a volatile memory or random access memory (VM) **145**, a demodulator (DEMOD) **146**, an application specific integrated circuit (ASIC) hardware-based servo controller ("servo engine") **148**, a digital to analog converter (DAC) **150** and a motor driver circuit **152**. Optionally, the controller **144**, the random access memory **145**, and the servo engine **148** are portions of an application specific integrated circuit **154**.

Typically, a portion of the random access memory **145** is used as a cache for data read from the information track **120** awaiting transfer to a host connected to the disc drive **100**, and for data transferred from the host to the disc drive **100** to be written to the information track **120**. The components of the servo control circuit **142** are utilized to facilitate track following algorithms for the actuator assembly **110** (of FIG. **1**) and more specifically for controlling the voice coil motor **122** in position-controlling the read/write head **118** relative to the selected information track **120** (of FIG. **1**).

The demodulator **146** conditions head position control information transduced from the information track **120** of the rotatable recording surface **109** to provide position information of the read/write head **118** relative to the information track **120**. The servo engine **148** generates servo control loop values used by the controller **144** in generating command signals such as seek signals used by voice coil motor **122** in executing seek commands. Control loop values are also used to maintain a predetermined position of the actuator assembly **110** during data transfer operations.

The command signals generated by the controller **144** and passed by the servo engine **148** are converted by the digital to analog converter **150** to analog control signals. The analog control signals are used by the motor driver circuit **152** in position-controlling the read/write head **118** relative to the selected information track **120**, during track following, and relative to the rotatable recording surface **109** during seek functions.

In addition to the servo control code program of the application specific integrated circuit **154**, control code is also programmed into the application specific integrated circuit **154** for use in executing and controlling data transfer functions between a host **156** and the disc drive **100**. Read/write channel electronics **158**, operating under control of the controller **144** executing the control code, passes data received from the host **156** to the read/write head **118** for storage on the disc **106** and passes data read by the read/write head **118** from the disc **106** back to the host **156**.

The read/write channel electronics **158** includes a servo variable gain amplifier (SVGA) **160**, which amplifies an amplitude of a head position control signal read from the information track **120**. The amplified amplitude of the head position control signal, provided by the servo variable gain amplifier **160**, is stored in a servo variable gain amplifier register **162** for subsequent release to, and processing by, the servo engine **148**.

It will be recognized that the height (distance) that a given read/write head **118** flies adjacent an associated disc surface will generally depend upon the rotational speed of the discs **106** and the particular characteristics of the head. While all of the heads **118** in a particular disc drive are designed to nominally fly at the same height for a selected rotational speed of the discs **106** (i.e., a nominal operational fly height), some amount of manufacturing variations will tend to be present in a given population of heads.

Thus, in a given disc drive **100**, some heads will tend to fly at a slightly higher than nominal operational fly height while other heads will tend to fly at a slightly lower than nominal operational fly height. The lowest flying head **118** in a disc drive **100** will typically land (i.e., contact its corresponding disc surface) before the other heads **118** in the drive as the discs **106** are decelerated to rest.

A particularly low flying head can accordingly pose a long term reliability risk for the drive. Drive manufacturers have employed a number of different methodologies in an attempt to screen for low flying heads during disc drive manufacturing operations.

The present invention (as embodied herein and as claimed below) provides a novel approach to characterizing the fly height characteristics of a selected head **118**. This novel approach entails an evaluation of the readback response of the head **118** reading a constant frequency pattern written to a corresponding disc while the corresponding disc decelerates from a nominal operating rotational velocity to a stationary state.

As will be recognized, an amplitude of a readback signal obtained from a selected head **118** will generally increase as the head **118** comes into closer proximity to the disc **106**. It has been found that a modulation of a readback signal of a constant frequency pattern written to the disc **106** commences just prior to the head **118** landing on the disc surface. Thus, monitoring the readback response of a head to a constancy frequency pattern provides a distinct read signal landing signature that can be used to accurately determine the fly height status of the head.

FIG. **3** shows a pair of read signals **170**, **172** plotted against a common elapsed time x-axis and a common signal amplitude y-axis. The signals **170**, **172** are both obtained from a selected head **118** as the head transduces a constant frequency pattern from the associated disc **106**, with the signal **170** obtained as the head **118** flies in close proximity to the disc surface just before contact and the signal **172** obtained as the head **118** flies at a higher fly-height.

It will be noted that the overall peak amplitudes of the respective read signals **170**, **172** are reasonably similar in value. What distinguishes the typical nominal read signal **172** from the close proximity read signal **170** is the presence of characteristic amplitude modulation **174** (i.e., the peak and valley variation of the amplitude across the read signal **170**). This characteristic amplitude modulation **174** provides a read signal landing signature that can be used as a reliable and repeatable indicator of the landing characteristics of the head **118**.

Table 1 provides a summary of data obtained for a population of five different heads (substantially similar to the heads **118** of FIG. **1**) showing the disc speeds (in disc rpm) when modulation of the amplitude of the readback signal were observed for various atmospheric conditions.

An atmospheric chamber was employed to simulate various altitudes. An increase in altitude results in a reduction in density of the available atmosphere, which reduces the amount of available lift for flying the read/write head **118** adjacent the disc **106** for any given disc speed. Less lift results in a lower fly height of read/write head **118** for any given disc speed.

Although some variations were observed in the specific disc speeds (rpms) at which the amplitude modulations occurred, the data showed a consistent trend in that higher flying heads tended to land at a lower rpm and lower flying heads tended to land at a higher rpm. By applying a threshold value suitable for the environment in which the discs **106** are rotated, heads that exhibit the amplitude modulation above said threshold value can be characterized as insufficiently low flying heads and removed from the manufacturing operation.

FIG. **4** provides a flow chart for a head flight characterization routine **200**, generally illustrative of steps carried out in accordance with preferred embodiments of the present invention. The routine is preferably carried out during manufacturing using a test stand or other suitable test equipment for a population of heads (such as **118**). The routine can also be carried out within the confines of a disc drive (such as **100**), as desired. Additionally, the routine may be carried out in either an ambient atmospheric environment or a reduced density atmospheric environment (such as helium enriched environment).

The first head (such as **118**) to be tested is selected at step **202**, and the associated disc (such as **106**) is accelerated at step **204** to a nominal rotational velocity. This results in the generation of an air bearing sufficient to fly the head **118** adjacent the disc surface, as indicated by step **206**. The head **118** is moved at step **208** to a position adjacent a region of the disc surface to which a constant frequency pattern is written. The pattern is preferably written to a region that is inaccessible for storage of customer data. The pattern can be prerecorded (such as during a prior servo track writing operation during which the servo data are written), or the pattern can be written during the operation of step **208** as desired.

An appropriate biasing of the head **118** (such as through application of a low level read bias current) is applied at step **210** to enable the head **118** to output a readback signal in response to the constant frequency pattern written to the disc surface. Monitoring of the readback response of the head is initiated at step **212**. At this point, the head **118** will generally provide a baseline response such as shown by the typical nominal read signal **172** in FIG. **3**.

The disc surface is next decelerated beginning at step **214** and continuous speed measurements are obtained as the disc surface decelerates to rest. As the head **118** comes closer to the disc surface, an amplitude modulation of the typical nominal read signal **172** will be determined at step **216**. This can be carried out by monitoring the output of a digital oscilloscope configured to display the readback response. The amplitude modulation can also be determined by monitoring an output response of a servo variable gain amplifier (such **160** in FIG. **2**).

An associated disc speed **S1** coincidental with the occurrence of the read signal landing signature is next identified at step **218** and compared to a preselected threshold value ST at step **220**. As shown by decision step **222**, when the disc speed **S1** is greater than or equal to the threshold value ST, the head selected is determined to have unsuitably low flying characteristic and the routine **200** passes to step **224** where the head is replaced or otherwise rejected from the manufacturing operation.

On the other hand, when the disc speed **S1** is less than the threshold value ST, the head is accepted for further operations. The routine then passes to decision step **226** which inquires whether additional heads remain to be tested. If so, the next head is selected at step **228** and the routine is repeated for the next selected head. Finally, when all heads have been tested in turn, the routine ends at step **230**.

In an alternate embodiment, each of the plurality of disc drives (such as **100**) are placed in an altitude chamber, the rotational velocity of the disc (such as **106**) is maintained at the nominal operating rotational velocity and a previously written constant frequency pattern present in a recording surface (such as **109**) of the disc is read while increasing the effective altitude experienced by the disc drive.

Upon encountering the read signal landing signature, the effective altitude experienced by the disc drive concurrent with the occurrence of the read signal landing signature is logged for each of the plurality of disc drives of the particular configuration being evaluated. The data are reviewed and a determination is made, taking into consideration any additional margin of safety thought appropriate, regarding an effective altitude threshold, and an effective altitude threshold is set.

In an additional alternate embodiment, an ambient atmosphere within each of the plurality of disc drives (such as **100**) is displaced with a lower density atmosphere, such as helium, at a predetermined rate; rotational velocity of the disc (such as **106**) is maintained at substantially the nominal operating rotational velocity; and a previously written constant frequency pattern present in the recording surface (such as **109**) of the disc is read while the ambient atmosphere is displaced. Displacement of the ambient atmosphere with a lower density atmosphere decreases the fly height of the read/write head (such as **118**).

Upon encountering the read signal landing signature, the rate dependent elapse time of the atmosphere displacement procedure is logged for each of the plurality of disc drives of the particular configuration being evaluated. The data are reviewed and a determination is made, taking into consideration any additional margin of safety thought appropriate, and an effective rate dependent elapsed time threshold is set.

It will be noted that the constant frequency pattern transduced during the operation of the routine of FIG. **4** preferably extends around a complete circumference of the disc surface. In such case no servo positioning data are present in the region to which the pattern is written. This will tend to prevent the servo circuit **154** from using such data to detect and correct the position of the head **118** to maintain the head over the pattern.

Thus, the region to which the constant frequency pattern is written is preferably selected so that the head **118** can be mechanically biased to remain over the pattern. For example, the pattern can be written to the landing zone **120**, and current can be supplied to the voice coil motor **122** to bias the actuator **110** against the inner limit stop and maintain the head **118** over the pattern. The pattern can alternatively be written to a guard track region at the outermost diameter of the discs **108** and current can be supplied to the voice coil motor **122** to bias the actuator **110** against the outer limit stop to maintain the head **118** over the pattern.

In another preferred embodiment, the head characterization takes place in a spin-stand to sort the heads prior to installation into the disc drive **100**, with the spin-stand providing suitable mechanisms to precisely maintain the head **118** in a desired relationship with the associated disc surface.

During the practice of preferred embodiments of the present invention, it will be understood that the operational rotational velocity of the disc **106** is determined by a product specification. The nominal configuration of the heads **118** is selected to accommodate a predetermined nominal fly-height during data transfer operations with the discs **106**. The frequency of the constant frequency pattern can be any suitable value based on a given configuration, and in a preferred embodiment corresponds to the write frequency used to write the servo data to the discs **106**.

The predetermined rotational velocity threshold used to separate low-flying heads from non low-flying heads is also empirically determined based on the drive configuration as well as other factors associated with a given application.

Accordingly, embodiments of the present invention are directed to categorization of a read/write head (such as **118**) of a disc drive (such as **100**) as a low-flying read/write head or a non low-flying read/write head. The categorization is based on an occurrence of a read signal landing signature (such as **170**) occurring prior to an encountering of a predetermined threshold. The read signal landing signature is based on a readback of a constant frequency pattern previously written to a recording surface (such as **109**) typically located within a region of the disc inaccessible for storage of customer data.

The readback of the previously written constant frequency pattern present in the recording surface occurs while a disc (such as **106**) decelerates from a nominal operating rotational velocity to a stationary state during a landing procedure.

FIG. **5** provides a system **300** configured to carry out the routine of FIG. **4** in accordance with preferred embodiments of the present invention. The system **300** includes several components discussed above including the disc **106**, head **118**, preamp **136** and read/write channel **158** shown in FIG. **2**. The system further preferably includes a housing **302** in which at least the head **118** and the disc **106** are disposed, a motor **304** used to rotate the disc **106** at a desired rotational speed, a control circuit **306** which provides overall control of the system **300**, and an analysis and display module **308**.

In a preferred embodiment, the system **300** is incorporated into a spin-stand in which multiple discs **106** and heads **118** are supported. In such case the heads **118** are preferably evaluated as part of a servo track writing operation in which the aforementioned servo information is written to the disc surfaces **109**. The control circuit **306** in this configuration can comprise a host computer alone or in conjunction with selected circuitry from FIG. **2** can be configured to carry out the routine of FIG. **4**. The module **308** can comprise a monitor of the computer or a separate data acquisition device (such as a digital oscilloscope).

In an alternative embodiment, the system **300** is embodied within the disc drive **100** so that the housing **302** corresponds to the housing formed by the base deck **102** and top cover **103**, the motor **304** corresponds to the spindle motor **104** (FIG. **1**) and the control circuit **306** corresponds to the controller **144** (FIG. **2**).

The module **308** can comprise a separate data acquisition device (such as a digital oscilloscope) with test probes placed in electrical communication with appropriate test points on the disc drive printed circuit board assembly to obtain data as shown in FIG. **3**. The display module **306** can also be incorporated into the circuitry of FIG. **2** such as by using suitable programming of the controller **144** so that the signature is detected in relation to baseline and peak values from the readback signals obtained from the head **118**.

Accordingly, embodiments of the present invention are generally directed to categorization of a read/write head (such as **118**) of a disc drive (such as **100**) as a low-flying read/write head or a non low-flying read/write head. The categorization is based on an occurrence of a read signal landing signature (such as **170**) occurring prior to an encountering of a predetermined threshold. The read signal landing signature is based on a readback of a constant frequency pattern written to a recording surface (such as **109**) located within a region of the disc inaccessible for storage of customer data. The readback of the constant frequency pattern present in the recording surface preferably occurs while a disc (such as **106**) decelerates from a nominal operating rotational velocity to a stationary state during a landing procedure.

For purposes of the appended claims, it will be understood that the disclosed structure corresponding to the recited first means comprises the circuitry shown in FIG. **5**.

It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While presently preferred embodiments have been described for purposes of this disclosure, numerous changes may be made which will readily suggest themselves to those skilled in the art and which are encompassed in the appended claims.

What is claimed is:

1. A method comprising:

supporting a transducer at a fly height adjacent a data storage medium by a predetermined force resulting from a first state of a fluid surrounding the transducer;

retrieving output data from the data storage medium;

altering a condition affecting the fluid by replacing the fluid with a different fluid having a different density to reduce the force until the output data indicates a response that is characteristic of a minimum noncontacting fly height at a second state of the fluid; and

comparing the altered condition associated with the fluid second state with a predetermined threshold to determine the transducer fly height performance.

2. The method of claim **1** wherein the condition is characterized by a dynamic fluid pressure that is proportional to data storage medium velocity.

3. The method of claim **1**, further comprising storing input data associated with the output data before the retrieving step.

4. The method of claim **3**, wherein the storing step comprises storing a constant frequency data pattern.

5. The method of claim **1**, wherein the condition is characterized by a static fluid pressure in relation to atmospheric pressure.

6. The method of claim **4** wherein the response is characterized by an amplitude modulation.

7. A system comprising:

a transducer adapted for a data storing and retrieving relationship with a data storage medium; and

means for determining fly height performance of the transducer by associating an observed occurrence of a characteristic output data signature response with an expected occurrence.

8. The system of claim **7**, wherein the means for determining is characterized by observing an amplitude modulation of the output data.

9. The system of claim **7**, wherein the means for determining is characterized by observing a gain oscillation of the output data.

10. The system of claim **7**, wherein the means for determining is characterized by storing input data associated with the output data with the transducer.

11. The system of claim **7**, wherein the means for determining is characterized by changing a velocity of the data storage medium.

12. The system of claim **7**, wherein the means for determining is characterized by changing a static pressure of a fluid aerodynamically supporting the transducer.

13. The system of claim **7**, wherein the means for determining is characterized by changing a density of a fluid supporting the transducer.

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